THE RELATION OF CARBON TO NITROGEN IN THE URINE, WITH A METHOD FOR THE ESTIMATION OF CARBON.

By H. Richardson, M.D.,
MOUNT HOPE RETREAT, MD.

The quantity of carbon taken into the system with the food during the twenty-four hours is very large, the greater part being eliminated by the lungs as CO$_2$, and the remainder by the urine and feces. The number of carbon metabolism experiments is not large, owing to the difficulties in estimating the elimination from the lungs. The most complete experiments have been made by W. O. Atwater, recorded in Bulletin No. 44 of the United States Department of Agriculture; he finds that with a daily intake of 234.0 C, 219.0 C, or 93.6 per cent. are eliminated by the lungs, leaving only 6.4 per cent. to be eliminated by the urine and feces. As the percentage eliminated by the urine is so small, it seemed probable that pathological conditions might make a variation in the relation of carbon to nitrogen.

The estimations of carbon in the following analyses are made by a modification of the ordinary wet method:

The urine was decomposed in an ordinary 500 c.cm. fractional distilling flask by means of a mixture of sulphuric and chromic acids, the carbon dioxide evolved passed through iodic acid, silver nitrate, and biniodate of sodium into a flask containing ammonia; the CO$_2$ is precipitated from the ammonia carbonate with BaCl$_2$, filtered, the precipitate dissolved in normal nitric acid and titrated back with semi-normal caustic potash; the amount of nitric acid required multiplied by 0.006 gives the amount of carbon.

In order to test the accuracy of the method, a solution of oxalic acid was made, containing 1.48 per cent. carbon, and the carbon estimated with the following results:

5 c.c. of the solution contained by calculation	0.074 C.	= 1.48 per cent. C.
Found in 5 c.c. of the solution	0.075	= 1.5 per cent.
" " "	0.0744	= 1.488 "
" " "	0.0738	= 1.476 "
" " "	0.0741	= 1.482 "

The following estimations were made with various specimens of urine, with the following results:

I.	5 c.c. urine contained	(a)	0.0351 C.	= 0.702 per cent.
	5 " " "	(b)	0.0349	= 0.698 "
II.	5 " " "	(a)	0.0525	= 1.05 "
	5 " " "	(b)	0.0507	= 1.014 "
III.	5 " " "	(a)	0.0606	= 1.212 "
	5 " " "	(b)	0.0594	= 1.188 "
IV.	5 " " "	(a)	0.0498	= 0.996 "
	5 " " "	(b)	0.0504	= 1.008 "

The variations in the above analyses come within the limitations of error, and I, therefore, consider the method reliable for the estimation of carbon in urine.

The relation of carbon to nitrogen is the point which has to be considered. In order to obtain a basis for the normal factor $\frac{C}{N}$, the following analyses were made from the twenty-four hours' urine of presumably healthy subjects. In every case two analyses were made and the mean taken.

Total quantity of urine in 24 hours.	Total carbon.	Total nitrogen.	$\frac{C}{N}$
I. 1170 c.cm.	9.9333	10.1965	0.97
II. 1750 "	16.0125	20.335	0.78
III. 1750 "	12.587	11.8662	1.1
IV. 1050 "	9.009	8.967	1.0
V. 910 "	11.811	18.7859	0.63
VI. 1170 "	15.3738	15.1017	1.01
VII. 680 "	7.616	10.224	0.74
VIII. 870 "	9.896	12.0338	0.78
IX. 900 "	9.855	11.8692	0.83

The variations in the above $\frac{C}{N}$ factors are from 0.63 to 1.1; of those of the two extremes, Nos. V. and III., No. V. had a gouty diathesis, and No. III. had a hypochlorhydria, so that the actual variations of those who were presumably healthy were from 0.74 to 1.01, giving a mean of 0.875, or about the same as the respiratory quotient.

A metabolism experiment was made extending over five days: the first three days the subject spent quietly in his room, the last two days he took strong exercise on his bicycle. The analyses of the food were all made with the exception of those marked (*), which were estimated.

TABLE A.

	Dec. 29 to 30.			Dec. 30 to 31.			Dec. 31 to Jan. 1.			Jan. 1 to 2.			Jan. 2 to 3.		
	Food taken	N	C	Food taken	N	C	Food taken	N	C	Food taken	N	C	Food taken	N	C
Eggs	140.0	2.9	20.16	135.5	2.81	19.5	208.5	4.87	30.02	120.0	2.62	17.28	133.0	2.79	19.15
Steak	357.0	12.49	41.41	316.0	11.0	38.8	172.0	6.02	23.82	350.0	12.25	41.1	357.0	11.02	43.55
Crackers	221.0	3.221	63.23	185.5	2.7	53.0	132.0	1.84	89.46	182.5	2.73	52.19	142.5	1.99	40.95
Butter	53.0	......	31.76	36.0	......	23.95	39.0	......	23.51	47.5	......	31.16	41.0	......	26.89
Sugar*	77.5	......	20.06	86.5	......	23.06	75.0	......	15.7	82.5	......	21.8	101.0	......	26.3
Milk	261.5	1.307	12.00	350.0	1.75	16.06	400.0	2.0	18.4	300.0	1.5	13.8	310.0	1.7	15.86
Rice	......	......	......	70.0	0.95	21.09	60.0	0.78	18.1	0.5	0.68	15.06	60.0	0.68	15.06
Total	......	19.91	194.67	......	19.31	195.48	......	15.01	170.64	......	19.68	185.50	......	18.18	187.96
Feces	20.0	1.21	8.83	20.0	1.21	8.38	20.0	1.21	8.38	20.0	1.21	8.38	20.0	1.21	8.38
$\frac{C}{N}$ of food	9.78	......	......	10.11	......	......	11.36	......	......	9.42	......	......	10.32		
$\frac{C}{N}$ of urine	0.88	......	......	0.75	......	......	0.73	......	......	0.85	......	......	0.73		

During rest the intake was 54.23 N and 560.69 C, giving a factor $\frac{C}{N} = 10.32$; the elimination of the urine and feces was 47.43 N and 58.08 C, giving a factor $\frac{C}{N} = 1.22$. The body gain of nitrogen was 6.8 N (42.5 protein), while the body gain of carbon plus that eliminated by the lungs was 502.08. During the two days of exercise the intake was 37.86 N and 373.35 C, being a factor $\frac{C}{N} = 9.6$, while the elimination was 33.39 N and 40.98 C, giving a factor $\frac{C}{N} = 1.23$, showing a body gain of 4.47 N, equal to 27.93 protein, and elimination of the lungs and body gain of carbon was 332.73 C. The average daily intake of carbon during rest was 186.89, and the average daily elimination of urine and feces was 19.36, leaving an average lung elimination of 167.53 C. During the two days' work the average daily intake of carbon was 186.6, and the daily elimination of urine and feces was 20.98, leaving 165.62 eliminated by the lungs.

From the above it appears that under normal conditions the proportion of carbon eliminated by the lungs, urine, and feces is practically the same on the same diet during rest and during a reasonable amount of exercise, and also that the factor $\frac{C}{N}$ in the urine is the same within narrow limits in a healthy subject.

In order further to test the difference between exercise and rest, the urine secreted during sleep and that excreted during the waking hours was collected from three healthy subjects. In these analyses the carbon was estimated in inorganic combination as well as the total carbon. Normally about one-third of the CO_2 in the blood is in loose combination with the hemoglobin, while the other two-thirds are either free or in combination with alkalies. The quantity of CO_2 in combination with hæmoglobin eliminated by the lungs will be fairly constant, while any variation would presumably rest with that in inorganic combination and would be eliminated by the urine as carbonate.

TABLE B.

	I.		II.		III.	
	Sleep.	Awake.	Sleep.	Awake.	Sleep.	Awake.
Total quantity of urine	310 c.c.	1135 c.c.	215 c.c.	780 c.c	230 c.c.	660 c.c
Number of hours	7	17	7	17	8½	15½
Total nitrogen	3.236	8.262	2.683	7.677	4.991	11.08
Nitrogen per hour	0.462	0.486	0.383	0.452	0.587	0.765
Carbon in organic combination	2.901	8.781	2.342	5.945	2.717	6.343
" " " per hour	0.414	0.516	0.331	0.35	0.32	0.409
" in inorganic combination	0.0658	0.1975	0.0318	0.1401	0.0172	0.1504
" " " per hour	0.0098	0.0116	0.0019	0.0082	0.002	0.0097
Total carbon	3.859	8.979	2.3768	6.085	2.76	6.494
" " per hour	0.513	0.528	0.339	0.358	0.324	0.411
$\frac{\text{Total C}}{\text{Total N}}$	1.2	1.08	0.88	0.79	0.67	0.58
$\frac{\text{Organic C}}{\text{Inorganic C}}$	62.7	45.51	67.8	42.2	63.6	42.1

In every case the total carbon and nitrogen eliminated per hour is less during sleep than while awake, while the factor $\frac{C}{N}$ is higher during sleep than waking. The inorganic carbon is less per hour during sleep, and the factor $\frac{\text{organic C}}{\text{inorganic C}}$ shows marked regularity.

Fr. Tangl, in *Arch. f. Anat. u. Physiol.*, 1899, has shown that in the dog the factor $\frac{C}{N}$ is the same both at rest and at work, but that diet makes a difference. He found that on fat diet $\frac{C}{N}$ was 0.691, while on a carbohydrate diet it was 0.944.

As the factor $\frac{C}{N}$ under normal conditions is constant within narrow limits, and is unaffected by rest or exercise, it follows that any great deviation from normal must be the result of some pathological condition. When the factor $\frac{C}{N}$ is high the patient may be on a carbohydrate diet, or he may be assimilating his carbohydrates and not assimilating his fats and proteids in proportion, or vice versa; if his factor is low he is either on a proteid fat diet or he is not assimilating his carbohydrates. There is also a possibility as to the condition of the blood making a variation in the factor. The carbon in acid carbonate combination is eliminated by the lungs with the formation of carbonate, and, therefore, the alkalinity of the blood must have an effect upon the carbon elimination. Waller, *Arch. Exper. Path. u. Pharm.* Bd. vii., found that in rabbits poisoned with HCl there was only from two to three volumes carbon dioxide in the blood. Geppert and Zuntz observed that the alkalinity of the blood in rabbits was diminished by the acid formed during tetanic convulsions, and at the same time the carbon dioxide of the blood was decreased. During diabetic coma the alkali of the blood is in part neutralized by the β-oxybutyric acid.

Minkowski found only 3.3 volumes of CO_2 per cent. in the blood of a patient suffering from diabetic coma. A diminished alkalinity of the blood causes a greater elimination of CO_2 of the lungs, and consequently a reduced elimination by the urine. An examination of the condition of the stomach in relation to the factor $\frac{C}{N}$ showed no constant variation; in a case of hyperacidity, with 84° free HCl, the factor $\frac{C}{N}$ was 1.5, while in cases where free HCl could not be detected in the stomach contents $\frac{C}{N}$ ranged from 1.0 to 1.2.

I have observed in gouty conditions that the factor $\frac{C}{N}$ is very low; in the twenty-four hours prior to a very severe attack it was 0.58, and in the same patient when fairly free from pain the factor $\frac{C}{N}$ was 0.63; in another case observed in the institution it was 0.61. From the results of several hundred urinary analyses in patients at the retreat and outside, I have come to the conclusion that when the $\frac{C}{N}$ factor is 0.7, or below, strong alkaline treatment is indicated. . . . .